The Vagus Nerve in the Domestic Cat (Felis domestica).

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The idea of using the cat as the basis of anatomical study is by no means a recent one. Straus-Durckheim's "Anatomie du Chat," Dr. B. G. Wilder's "Anatomical Uses of the Cat," and other papers published by the same author since 1877, and Mivart's recent work on "The Cat," present the general thought with more or less directness. I am not aware, however, that any one has made a study of the nerves of the cat in their detailed distribution. Having compared the vagus nerve in man, cat, dog, horse, ox, sheep, rabbit and frog, I am satisfied that the cat (*Felis domestica*) presents advantages over all others as a basis for comparative study. I accordingly submit the accompanying figures and text to aid students who may be disposed to investigate Comparative Neurology.

The cat, dog, and rabbit were injected with plaster, as recommended by Prof. Simon H. Gage, of Cornell University, in a paper published in The American Naturalist, vol. xii, p. 717. The figures are semi-diagrammatic; they were originally drawn to a scale, natural size; for the purpose of giving prominence to certain relations, to ramuli and anastomotic filaments, such modifications have been made as seemed necessary; where a nerve trunk is continuous, with no distinctive characters, it is shortened, e.g., the gastro-cardiac portions of the vagus (Fig. 9). The figure of the stomach is reduced one-half (Fig. 13). For the sake of simplicity no attempt has been made to reproduce plexuses or the terminal ramification of filaments.

The nomenclature used is largely that advocated by Dr. B. G. Wilder, before the American Association for the Advancement of Science, at Boston, 1880, in a paper entitled "A Partial Revision of the Nomenclature of the Brain," and in a more detailed communication published in Science, March 19, and 26, 1881, entitled "A partial Revision of Anatomical Nomenclature, with especial reference to that of the Brain." The simplicity and perspicuity of the nomenclature commend it alike to the lecture-room and the laboratory.

[In cases where it was thought that any possible doubt might arise from using the new terminology, the new words are followed by their anthropotomical equivalents.]

The vagus nerve (N. vagus; N, pneumogastricus; Pars vaga; Par vagum; N. ambulatorius; N. sympathicus medius; Eighth pair, pneumogastric branch, Willis; Tenth pair, Sömmering and Vicq-d'Azyr) presents the following marked characters, viz:—

General Characters: N. vagus has the most extensive distribution and the longest course of the cranial nerves; in its cephalic region principal rami are derived from ganglia; it forms by its frequent and complex anastomoses with N. sympathicus numerous plexuses, hence presents involved physiological and pathological complications; its terminal fila-

ments supply the muscular substance and the mucous membranes of organs; its development in relation with the development of, notably, the heart and adjacent blood-vessels, and the stomach, renders its distribution somewhat asymmetrical, necessitating special anatomical study of its dextral and sinistral relations, and giving corresponding and distinctive physiological and pathological characters; the relation of this nerve to organic life, to the automatic and the reflex phenomena of respiration, and to the so-called "inhibitory phenomena" gives importance to its study.

Special anatomical characters: N. vagus and its rami are distributed to the most important viscera, at least to viscera most intimately related to the functions of organic life, e. g., *digestive*—pharynx, œsophagus, stomach, liver, pancreas, intestines; *circulatory*—heart, pulmonary arteries, pulmonary veins, systemic arteries and veins in the region of the heart; *respiratory*—larynx, trachea, bronchi, substance of lung.

Special physiological characters: N. vagus is a sensory-motor nerve, having both sensitive and motor fibres; it controls, regulates or modifies the movements and the secretory functions of the organs to which it is distributed, and upon it depend the sensory phenomena which characterize the respective organs.

DESCRIPTION: Origin and cervical portion—N. vagus in the cat (*Felis domestica*) takes its superficial origin from two regions of the medulla: by 12–14 filaments from the ventral border of corpus restiforme and the depression line between cp. restiforme and the portion of medulla next laterad (Fig. 3, 4),* in a line caudad of (posterior to) the origin-filaments of N. glosso-pharyngeus (ninth pair of cranial nerves), (Fig. 2, 4), from which nerve it is sometimes separated by a small arterial twig of A. cerebellosa inferior; and by 4–6 filaments immediately ventrad in the slight depression line ventrad of oliva and cephalad of the origin-filaments of the spinal portion of N. accessorius (Fig. 2. L). The dorsal filaments form a somewhat curved line of superficial origin, measuring 3–4 mm. in caudo-cephalic direction, and presenting its convexity dorsad (Fig. 2. X); the cephalic filaments are most ventral and leave the medulla oblongata just caudad of A. cerebellosa inferior—a considerable branch of A. basilaris at right angles with the main trunk and

* There is some difficulty in establishing satisfactorily the homologies of the medulla. There are reasons for regarding the third nerve tract from the dorsimeson as the homologue of corpus olivarium: this is manifestly not the cp. olivarium of Foster as given in his "Practical Physiology;" it should be noticed that the cephalic origin-filaments of N. accessorius become apparent in this depression line, while the caudal origin-filaments appear along the depression line ventrad of this tract. The elliptical area (Fig. 1, 3) laterad of ventripyramis (anterior pyramid) and the one still dorso-lateral have relations upon which homologies might be based, giving each one the name oliva (corpus olivarium). It is not proper in this connection to discuss homologies. I have made this allusion in apology for the indefiniteness of description of the origin-line of N. vagus. Whatever homologies may be established and names assigned, the figures (Fig. 3, 4) designate the relation.

given off 4–6 mm. cephalad of union of AA. vertebrales. These filaments unite about 1 mm. peripherad of their superficial origin into six or seven ramuli, which lie ventrad of plexus choroideus lateralis (Fig. 2, Pl. Ch.), and blend in foramen jugulare to form a single flattened nerve trunk, N. vagus. In the **passage through the foramen** 6 mm. peripherad of its origin, N. vagus is enclosed in common with N. accessorius (XI) in a sheath formed by a tubular prolongation of the dura mater and the arachnoid membrane, where it is also joined by N. glosso-pharyngeus (IX); but the sheath of the united NN. vagus (X) and accessorius (XI) may be readily dissected from that of N. glosso-pharyngeus (IX), which lies ectad and cephalad. Centrad of its foramen of exit—Foramen jugulare, (Foramen lacerum-posterius, Lacerum foramen posterius)—and 3–4 mm. peripherad of medulla oblongata, N. vagus presents a ganglionic enlargement, **ganglion jugulare,** ganglion of the root. This ganglion is hemispherical in form, of a grayish color, and measures nearly 2 mm. in diameter; it has relations with NN. facialis, glosso-pharyngeus, accessorius and sympathicus (Fig. 5, J).

At G. jugulare, N. vagus is connected by a single twig with the adjacent petrous ganglion of N. glosso-pharyngeus (IX) the "ganglion of Andersch" (Fig. 5, Pe.); by a considerable trunk with N. accessorius (Fig. 6, *10*); by ramus auricularis (Fig. 5, *2*), with N. facialis (VII), from which ramus, a slender ramulus penetrates the petrous bone and joins a branch of N. facialis; a portion of the ramus continues across N. facialis to the cochlea (Fig. 5, *5*), a filament from the auricular branch connects with a ganglionic plexus of N. sympathicus, entad of the gangliform plexus of N. vagus.

Plexus gangliformis. The 5 mm. of N. vagus immediately caudad of G. jugulare is involved in a somewhat intricate net-work, which seems to be allied to plexus gangliformis (Fig. 6., Px. gang.); the apposed trunks of NN. glosso-pharyngeus (IX), vagus (X), accessorius (XI) and hypoglossus (XII), are embraced by interlacing filaments of N. sympathicus, with which nerve they sustain more or less intimate relations, through anastomotic filaments; N. glosso-pharyngeus is ectal in this group, and, together with its root-ganglion—G. Ehrenritteri, which lies upon the ectal surface of G. jugulare, but which does not seem to sustain anatomical relations with it—may be dissected from the ental trunk; NN. vagus and accessorius are most intimately related—their separation involving the rupture of interlacing fibre—and apparently constitute a single trunk; entad of this united trunk is N. hypoglossus. At the caudal border of this plexus N. accessorius is directed dorsad to be distributed to the muscles of the neck, and N. hypoglossus assumes ectal relations, crossing the ectal surface of N. vagus nearly at right angles, and takes its course ventrad, to the muscles of the tongue. As N. hypoglossus crosses N. vagus, it detaches a filament to G. inferius (Fig. 5, *13*). This region marks the origins of two other rami with whose terminal filaments N. vagus sustains intimate relations, NN. thyro-hyoideus and descendens noni.

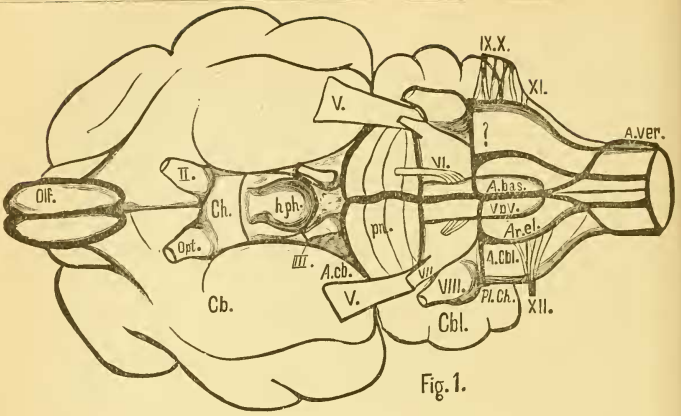


Fig. 1.

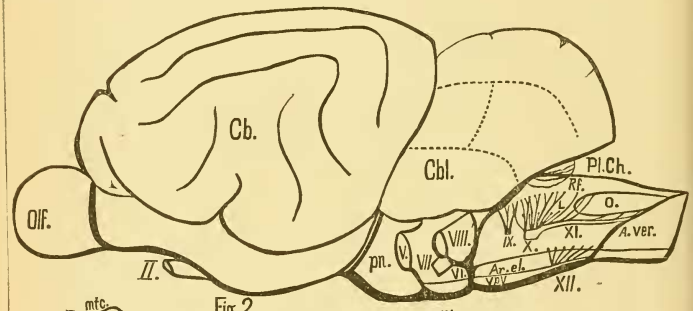


Fig. 2.

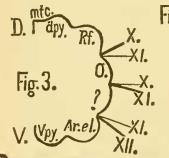


Fig. 3.

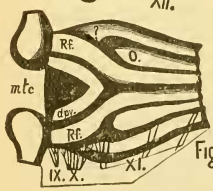


Fig. 4.

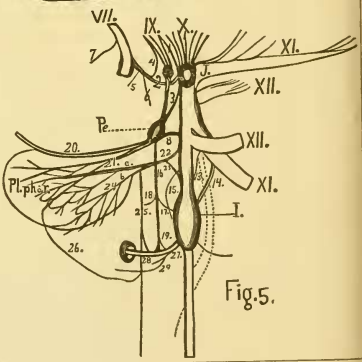


Fig. 5.

15 mm. caudad of G. jugulare and dorsad of the origin of A. carotidea interna, N. vagus receives a second ganglionic enlargement, **ganglion inferius,** ganglion of the trunk (Fig. 5, I.). This ganglion has a fusiform outline 5–8 mm. in caudo-cephalic diameter and 2 mm. in dorso-ventral; it is of a pinkish color; is located ectad of (superficial to) and dorso-caudad of the closely-apposed superior cervical ganglion of N. sympathicus, to which it is very intimately related through anastomotic filaments; its cephalic extremity is apposed to the middle of the superior cervical ganglion. G. inferius does not embrace or involve the main trunk of N. accessorius; it is however joined at its dorso-cephalic border by a large ramus given off from N. accessorius just peripherad of Px. gangliformis (Fig. 5, *14*); it is the superficial origin of a large ramus of N. vagus, viz., N. laryngeus superior; it communicates with N. glosso-pharyngeus (IX) (Fig. 5, *17*), N. accessorius (XI) (Fig. 5, *14*), N. hypoglossus (XII) (Fig. 5, *13*), with the spinal nerves NN. vertebrales, in the loop which connects the first and second cervical nerves, and with N. sympathicus (entad of Px. gangliformis).

In the cervical region N. vagus continues caudad from G. inferius associated with N. sympathicus in the sheath of A. carotidea primitiva. In the cephalic 20 mm. the trunk lies dorso-laterad of A. carotidea externa and A. carotidea primitiva, being concealed within the arterial sheath by the artery and by V. jugularis interna. As the nerve approaches A. occipitalis (?)* it lies laterad of A. carotidea primitiva and crosses the venter of A. occipitalis (?) at its origin; it resumes its dorso-lateral relation 5–8 mm. caudad of A. occipitalis (?) until it enters the thorax. The trunk of N. vagus in its cervical region caudad of G. inferius gives off several ramuli which anastomose with ramuli of N. sympathicus to constitute a more or less dense plexus around the trachea and œsophagus; this is especially marked in the caudal portion of the cervical region. The distinctive courses of the sinistral and the dextral nerves in the thorax require separate descriptions.

The principal rami of the cervical portion of N. vagus are Rm. auricularis, N. pharyngeus, and N. laryngeus superior.

Rm. auricularis, is a large anastomotic branch and has its superficial origin in the dorso-ental border of G. jugulare; its course is curved dorso-laterad and cephalad, and it enters the periotic bone, follows a groove along the dorso-caudal border of the tympanic bulla, traverses the petrous portion of the bone and enters aqueductus Fallopii at a point 2 mm. centrad of the origin of chorda tympani; a portion of Rm. auricularis continues to the opening where it meets the dorsal branch of N. facialis, to be distributed to the ear. A considerable fasciculus crosses N. facialis and may be traced to the cochlea (Fig. 5, *5*). 2 mm. peripherad of its origin Rm. auricularis receives a considerable twig from N. glosso-pharyngeus (IX), and about

* This artery, 25 mm. caudad of foramen of exit and dorsad, or 1–3 mm. dorso-cephalad of A. thyreoidea superior, seems to be allied to A. princeps cervicis. There are some objections to this homology, but the measurements given in the text identify it beyond question.

the same distance, still peripherad, an anastomotic filament from N. sympathicus (Fig. 5, *6*).*

N. pharyngeus, the pharyngeal branch, takes its superficial origin from the ventro-ental surface of N. vagus just caudad of the united trunks of NN. vagus and accessorius, 7 mm. caudad of G. jugulare and entad of the point where N. hypoglossus (XII) lies ectad of N. vagus; its origin is, therefore, involved in Px. gangliformis. A considerable accession is traceable through the plexus to the accessory branch of N. accessorius. Its course is ventrad, parallel with N. glosso-pharyngeus (IX), and only 2–3 mm. caudad of that nerve; it lies ectad of A. carotidea interna, and entad of V. jugularis interna and A. carotidea externa; just peripherad of its origin it gives a twig caudad to the trunk, which may be traced to G. inferius (Fig. 5, *23*). Opposite A. carotidea interna it divides into two rami (Fig. 5, *22*, a, b), from which filaments are given to A. carotidea interna and to the adjacent V. jugularis interna. From the *cephalic ramus* anastomotic filaments join N. glosso-pharyngeus (IX) to form a plexus, from which filaments are distributed to the cephalic border of MM. pharyngis constrictor medius, and pharyngis constrictor superior; others anastomose with filaments of N. sympathicus and form the pharyngeal plexus (Fig. 5), other filaments join N. hypoglossus (XII) in this plexus. The *caudal ramus* has its general course caudad; 5 mm. peripherad of its origin, it subdivides into two ramuli, which may be designated, in view of their distribution, as the pharyngeal (Fig. 5–*24*), and the œsophageal (Fig. 5, *25*); the *pharyngeal ramulus* is directed meso-dorsad and forms a loose network with the terminal filaments of the pharyngeal ramuli of N. glosso-pharyngeus (IX)—Px. pharyngeus. The *œsophageal ramulus* gives filaments to MM. pharyngis constrictor medius and pharyngis constrictor inferior. 10–12 mm. caudad of the filaments to the muscles of the pharynx a considerable twig joins the cephalic ramus of N. laryngeus superior and receives an anastomotic filament from the caudal ramus of the same nerve. The œsophageal ramulus continues along the dorsum of the œsophagus caudad as far as the caudal third of the cervical portion, interlacing in the plexus around that viscus.*

N. laryngeus superior, the superior laryngeal branch, is considerably larger than N. pharyngeus; it takes its superficial origin from the ventral border of the middle region of G. inferius; its course is immediately ventrad—occasionally it is directed caudad apposed to the main trunk and ectad of N. sympathicus, 8–10 mm., at which point it turns ventrad—and passes entad of A. carotidea primitiva, where it bifurcates into a cephalic, ental, ramus, *N. laryngeus internus* (Fig. 5, 7, *28*) and a caudal, ectal, ramus, *N. laryngeus externus* (Fig. 7, *29*).

N. laryngeus internus is much larger than N. laryngeus externus; it accompanies A. laryngea superior, and with the artery perforates the hyo-thyroid membrane at the ventro-caudal border of the cephalic cornu

* It sometimes occurs that the caudal ramus is detached caudad of the cephalic ramus of N. pharyngeus; in this case it constitutes a second pharyngeal nerve; this arrangement does not change its distribution.

of Ctl. thyroidea—A. laryngea superior is given off from A. carotidea externa, just caudad of the origin of A. carotidea interna; its course is, therefore, at right angles with A. carotidea externa,

N. laryngeus externus lies ectad of the larynx; it sends a pharyngeal ramulus cephalad and entad of A. laryngea superior (Fig. 7, *30*), which is distributed to M. constrictor pharyngis inferior, anastomoses with the œsophageal ramus of N. pharyngeus (Fig. 7, *31*), gives terminal filaments to Px. pharyngeus and the pharyngeal mucous membrane; filaments of this ramulus anastomose with N. crico-thyroideus and unite in plexiform relation with N. sympathicus around A. thyroidea superior; a twig of this pharyngeal ramulus detached just dorsad of the hyo-thyroid foramen, passes ventro-caudad to terminate in M. crico-thyroideus. This ramus sends a laryngeal ramulus ventro-caudad which lies entad of M. sterno-thyroideus, to which a few filaments are distributed, and is apposed to A. laryngea inferior, which artery it accompanies to the cricoid membrane as far as the ventrimeson (Fig. 7, *32*); from this ramulus filaments are given to M. crico-thyroideus. A caudal ramulus is also detached whose course is dorsad of M. sterno-thyroideus and parallel with its dorsal border to Cp. thyroideum (Fig. 7, *33*); it gives filaments to M. crico-thyroideus and anastomotic filaments to N. descendens noni, which it joins opposite the origin of A. thyroidea superior.

N. laryngeus internus enters the hyo-thyroid foramen and divides into a cephalic and a caudal offset: the *cephalic offset* (Fig. 7, *34*) accompanies the ental portion of A. laryngea superior, pierces M. thyro-arytænoideus to which numerous filaments are distributed, takes its cephalic course obliquely toward the ventrimeson and perforates the thyro-hyoid membrane 2 mm. laterad of the meson. Terminal filaments of this offset supply the epiglottis (Fig. 7, *36*), the arytæno-epiglottidean folds (Id. *37*), the laryngeal glands (Id. *35*), and the mucous membrane of the larynx (Id. *35*, a). A twig given from the cephalic offset, 2 mm. peripherad of the foramen, passes entad of the apposed artery (A. laryngea superior entalis) and joins the caudal offset 2 mm. cephalad of the caudal border of Ctl. thyroidea (Fig. 7 and 8, *39*).

The *caudal offset* lies closely apposed to the ental surface of Ctl. thyroidea (Fig. 7 and 8, *38*); its first twig is sent dorso-caudad and terminates upon M. crico-arytænoideus lateralis, M. arytænoideus and M. constrictor pharyngis inferior (Fig. 8, *40*); anastomotic filaments join in plexiform relation with its dextral homologue and with the pharyngeal and œsophageal plexuses. The principal portion of the caudal offset at its union with the twig from the cephalic offset gives off radiating filaments upon the ectal surface of the arytænoid muscles which constitute a multiple palmate plexus (Fig. 8, *41*.); a twig passes dorsad of the articular facet of Ctl. cricoidea and joins N. laryngeus inferior (Fig. 8. *42*). Near the union of the twig and the offset, entad of cephalic border of Ctl. cricoidea several filaments penetrate M. crico-arytænoideus and are distributed upon the mucous membrane of the larynx.

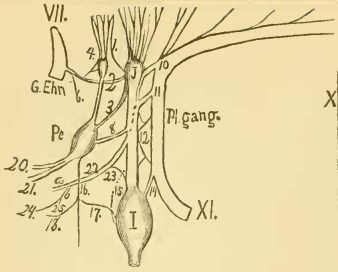
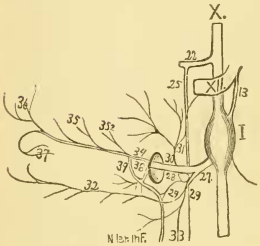


Fig. 6.



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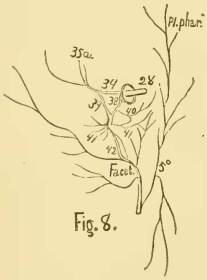

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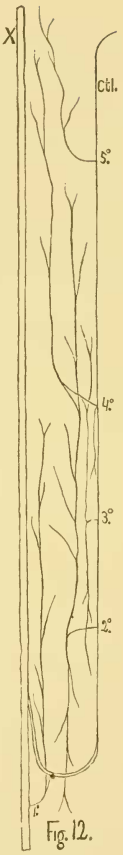
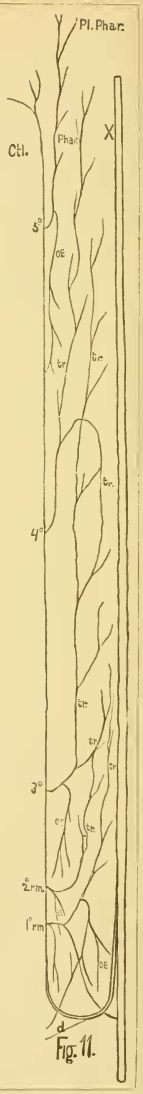


Fig. 12.



Thoracic division of N. vagus sinister: The main trunk of N. vagus sinister enters the thorax dorsad of V. innominata sinistra at the union of V. subclavia and V. jugularis externa, meso-dorsad of V. vertebralis and laterad of A. carotidea primitiva sinistra. In the thorax cephalad of the arch of A. aorta the nerve lies between AA. carotidea and subclavia meso-dorsad of A. sternalis until it reaches a point 10–15 mm. cephalad of A. aorta, at which point it rests upon the ventral surface of A. subclavia and crosses the arch ventro-laterad of the origin of A. subclavia. Opposite the origin of A. sternalis the nerve is crossed by N. phrenicus and lies dorso-laterad of this nerve in the area between the two arteries aforenamed.

As N. vagus enters the thorax, two fasciculi from the middle and caudal areas respectively of the middle cervical ganglion of N. sympathicus, G. thyreoideum, connect N. vagus with N. sympathicus; these commissural fasciculi are about 3 mm. apart. Between a point opposite A. sternalis and the arch of A. aorta the trunk of N. vagus sustains intimate relations with N. sympathicus, N. cardiacus magnus and N. cardiacus minor through numerous anastomotic filaments which constitute a plexiform network around the arteries, trachea and œsophagus in this region of the thorax—AA. subclaviæ, carotideæ primitivæ and innominata. Opposite the caudal border of the arch of A. aorta a considerable fasciculus from the main trunk about 5 mm. in length joins N. laryngeus inferior, 7 mm. peripherad of this fasciculus, where N. largyneus inferior bends around the arch of A. aorta, a ramulus is given off whose interlacings with rami from NN. vagus and sympathicus constitute a plexiform network which is related with the cardiac plexus. In its course caudad of arch of A. aorta. N. vagus passes dorsad of the root of the left lung.

Pulmonary Rami: Between a point opposite the cephalic border of A. pulmonaris and 15 mm. caudad, N. vagus gives several ramuli meso-ventrad to anastomose with terminal filaments of N. cardiacus minor and N. laryngeus inferior in the formotion of the ectal (superficial) cardiac and the ventral (anterior) pulmonary plexuses. From the same region of the main trunk filaments are directed meso-dorsad, which interlace in a dense network with filaments of offsets detached from the main trunk of the area above named, and with terminal filaments of N. cardiacus minor, and other filaments from N. sympathicus to form on the ventral aspect of the trachea just cephalad of its bifurcation, a large plexus, the ental cardiac—*Px. profundus magnus*—from which filaments ramify upon the bronchi and have intimate relations with the plexiform network which is formed by filaments from the offsets named and accessory offsets from thoracic ganglia of N. sympathicus around the bronchi,—dorsal pulmonary plexus. Offsets from this plexus may be traced along the air tubes into the substance of the several lobes and upon the broncho-pulmonary mucous membrane of the sinistral lung. The ramuli which form the dorsal pulmonary plexus are noticeably larger than those given to the ventral plexus.

Œsophageal Rami: Cephalad and caudad of the pulmonary rami

numerous filaments are directed dorsad, by whose anastomoses and union with N. sympathicus is formed the œsophageal plexus which embraces the entire length of the thoracic œsophagus. Caudad of the ramuli given to the pulmonary plexus, 15–20 mm. caudad of the caudal border of the arch of A. aorta, N. vagus sinister divides into sinistral or lateral and dextral or mesal rami (Fig. 9, *46*) which lie respectively upon the sinistral dorsum and venter of the adjacent œsophagus. The *lateral ramus* trends dorso-caudad, and 50–60 mm. peripherad of its origin it unites with the lateral ramus of N. vagus dexter in a median line upon the dorsum of the œsophagus, to constitute a single dorsal trunk for about 25 mm. (Fig. 9, *47*). Numerous anastomotic filaments from the two rami of N. vagus sinister and the rami of N. vagus dexter interlace in the œsophageal plexus from which filaments are given to the muscular tissue and mucous membrane of the œsophagus. The united dorsal trunk perforates the diaphragm and enters the abdomen as the *gastric nerve*.

The *mesal ramus* of N. vagus sinister trends ventro-caudad, and 20–25 mm. peripherad of its origin is joined by its dextral homologue (Fig. 9, *48*), and these two mesal rami constitute a united ventral trunk which lies in the caudal mediastinum upon the venter of the œsophagus and perforating the diaphragm near the meson, lies on the venter of the cardia (Fig. *13*). A slight twig connects the two mesal rami 2 mm. peripherad of their origins. From the thoracic portion of the ventral trunk anastomotic filaments are given to its homologue in the formation of the œsophageal plexus.

The thoracic portion of N. vagus dexter lies ventrad of A. subclavia and mesad of A. sternalis; at the caudal border of A. subclavia it bends slightly dorsad to pass mesad of V. vertebralis at its junction with V. innominata, it continues laterad of the trachea, entad of V. azygos and dorsad of the root of the right lung. As the main trunk enters the thorax it sustains intimate relations through anastomotic twigs with N. cardiacus magnus, N. cardiacus minor and the inferior cervical ganglion of N. sympathicus (Fig. 10). 15 mm. caudad of A. subclavia a considerable ramus is directed meso-caudad and accompanies a large ramus detached entad of V. azygos; these cardiac rami pass meso-ventrad around the base of the right pulmonary artery and to the right auricle (Px. cardiacus ectalis). Three or four ramuli are given off between A. subclavia and V. azygos whose ramifications interlace the plexus of the trachea and œsophagus. From the 12–14 mm. of the trunk dorsad of the lung, numerous filaments are directed mesad and ventrad to join the pulmonary plexus (Fig. 9). Caudad of this point and opposite the bifurcation of its sinistral homologue the dextral nerve bifurcates into lateral and mesal rami (Fig. 9, *49*); caudad of the bifurcation the lateral ramus trends dorso-caudad until it joins its sinistral homologue already described. The mesal ramus gives recurrent ramuli cephalad to the dextral border of the pulmonary plexus. Several other anastomotic filaments are detached from the ramus between the root of the lung and the union with its fellow which terminate in the œsophageal plexus (Fig. 9).

NN. laryngei inferiores, recurrent or inferior branches of N. vagus, tracheal recurrents, have the following *general characters in common*, viz.: their general cephalic direction; their disposition along the dorso-lateral border of the trachea; the anastomotic character of their ramuli; the distribution of the terminal filaments; the sensory function of the fibre. *Distinctive characters:* their origin; their length; their disposition in the thorax; the relative number of anastomotic filaments; the number of tracheo-œsophageal ramuli.

Special description: *N. laryngeus inferior sinister*, the sinistral recurrent nerve, branches from the mesal aspect of the main trunk of N. vagus, 1–3 mm. cephalad of the arch of A. aorta (Fig. 9, 45);* its course is caudad, apposed to the mesal side of the main trunk as far as the root of A. subclavia sinistra where the main trunk crosses the arch of A. aorta. Upon the ventral aspect of the arch of A. aorta, N. laryngeus inferior separates from the main trunk upon the mesal side, and twisting around the concave aspect of the arch about 1 mm. sinistrad of the obliterated "ductus arteriosus," it trends meso-dorsad, and returns cephalad along the dorso-lateral border of the trachea, between the trachea and the œsophagus, as a "recurrent nerve" (Fig. 9, *50*). At the caudal border of the larynx N. laryngeus detaches several ectal filaments to M. crico-thyroideus (Fig. 8), passes entad of a caudal twig of A. thyroidea superior, bends dorsad around the articular facet of Ctl. cricoidea (Fig. 8) and enters the larynx as an ental nerve. A slender anastomotic twig passes ectad of the arterial twig named and may be traced dorsad of the nerve trunk until it joins a corresponding twig from the caudal division of N. laryngeus superior (Fig. 7, *29*, a). Pharyngeal ramuli from the ental nerve are distributed to M. constrictor pharyngis inferior; other dorsal filaments supply M. arytænoideus posterior and M. arytænoideus; ventral filaments supply MM. crico-arytænoideus lateralis and thyro-arytænoideus, while terminal filaments reach the sub-glottic mucous membrane. Upon the ectal surfaces of MM. crico-arytænoideus posterior and crico-arytænoideus lateralis a multiple palmate plexus is formed by anastomotic filaments of NN. laryngeus superior and laryngeus inferior (Fig. 8, *41*).

N. laryngeus inferior dexter is detached from the main trunk of N. vagus, 12 mm. cephalad of the origin of A. subclavia, where the main trunk is disposed upon the ventral aspect of A. subclavia (Fig. 10); N. laryngeus dexter is immediately directed caudad over the venter of the artery, is reflected around the caudal aspect, and assumes a meso-dorsal direction to the dextral side of the trachea, and is disposed like its sinistral homologue, with the exception of having fewer anastomotic filaments. Peripherad of the origin of N. laryngeus inferior dexter, dorsad of A. subclavia, ramuli are given to the deep cardiac and the posterior pulmonary plexuses; another ramulus cephalad joins its sinistral fellow, a third, the thoracic cardiac, is directed caudad by the side of the main trunk of N. vagus dexter, and terminates in the dextral bronchial plexus. As N.

* An occasional origin is 8–10 mm. cephalad of cephalic border of arch of A. aorta.

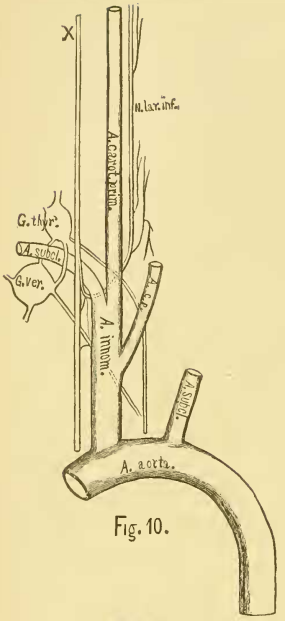


Fig. 10.

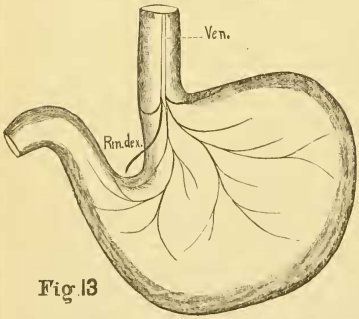


Fig. 13

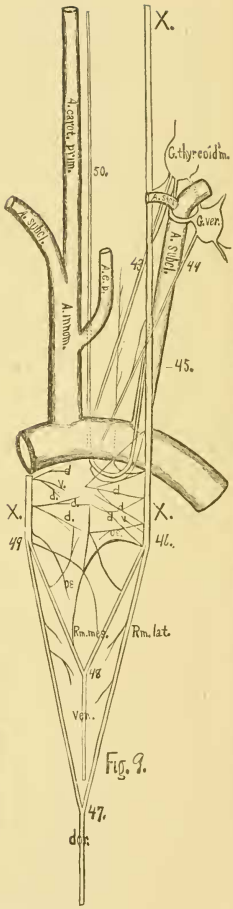


Fig. 9.

laryngeus inferior dexter bends around A. subclavia, just dorsad of A. sternalis, a branch is given off caudad, which, 10–12 mm. from its origin, joins N. cardiacus minor (Fig. 10), and these apposed trunks are joined 5 mm. peripherad by N. cardiacus magnus dexter, and the trunk thus constituted passes dorsad of V. cava descendens and A. innominata to the dorso-caudal border of the arch of A. aorta, where it terminates in Px. magnus profundus, from which filaments proceed to the ventral and dorsal coronary and the pulmonary plexuses.

Tracheo-œsophageal ramuli of N. laryngeus inferior (Fig. 11, 12). *General characters:* these ramuli of the sinistral and dextral nerves have in common the following characters—their origin; general direction; numerous terminal filaments; the plexiform relation of these filaments; their mode of entering larynx; their distribution upon its mucous membrane; distribution of the dorsal filaments to œsophagus. *Distinctive characters:* the smaller number of ramuli from the dextral side than from the sinistral; the homologue of the first sinistral nerve is always found as a ramulus from the main trunk caudad of the origin of N. laryngeus inferior dexter (Fig. 12); the terminal filaments of the dextral side are less numerous than those of the corresponding nerves of the sinistral side.* *Special description:* opposite the cephalic border of the arch of A. aorta the first tracheal ramulus is detached (Fig. 11, 1ºrm.); a considerable offset is directed caudad from the origin to Px. magnus profundus; 2 mm. peripherad of origin an anastomotic filament joins N. vagus 8 mm. caudad of origin of N. laryngeus inferior; 6 mm. peripherad of origin the ramulus bifurcates, the longer division is distributed upon the dorsum of the trachea 30 mm. cephalad of the arch of A. aorta; the shorter or caudal division sends filaments to Px. cardiacus ventralis, to Px. magnus profundus and to the bronchioli.

Five mm. cephalad of the first ramulus a second is given to the venter and the sides of the trachea over that portion corresponding to the distribution of the cephalic division of the first ramus upon the dorsum.

Ten mm. cephalad of the second ramulus and nearly opposite the origin of A. sternalis, the longest ramulus is detached; this divides into three offsets, the caudal is distributed to the venter of the œsophagus, the median to the sides of the trachea, the cephalic lies just laterad of the ventrimeson and gives two considerable fasciculi, whose terminal filaments supply the walls of the trachea; the terminal filaments of the ramulus are traceable nearly to Ctl. cricoidea.

Opposite the sixth cervical vertebra the fourth ramulus is detached, whose filaments anastomose with the preceding ramulus, and supply the dorsum of the trachea and venter of adjacent œsophagus along the entire cervical region from the thorax to the larynx.

The fifth tracheal ramulus takes its origin 10mm. caudad of Ctl. cricoidea

* The double ramuli sometimes occur with separate origins; this apparent increase of ramuli may be regarded as a modification and not a violation of the plan. In the special description the details of measurements of a single specimen are given.

(Fig. 8 and 11, 5°). This ramulus is largely if not exclusively œsophageal and joins in Px. pharyngeus; the caudal or recurrent portion is reflected caudad upon the œsophagus.

Gastric nerves: Caudad of the diaphragm the **dorsal gastric nerve** splits into several terminal ramuli, the longest of which terminates in ganglion semi-lunare of the great solar plexus, *Px. solaris;* near the cardia numerous filaments are distributed to the cardia; offsets supply the lesser curvature of the stomach, the plexus around A. coronaria ventriculi, and the dorsal surface of the stomach; ramuli may be traced to the plexus around A. hepatica (Px. hepaticus), A. splenica (Px. splenicus), A. mesenterica superior (Px. mesaræicus). At the cardia, terminal filaments of the **ventral trunk** are distributed to the lesser curvature of the stomach, a few join terminal filaments of the dorsal trunk (Fig. 13), and others still may be traced to the great solar plexus, from which ramuli enter the gastro-hepatic omentum and join the hepatic plexus. This anastomosis of the dorsal and ventral trunks in the solar plexus constitutes the "memorable loop of Wrisberg."

SUMMARY.

A. Anatomical. 1. Origin—12–14 filaments along a line ventro-laterad of Cp. restiforme, and by 4–6 filaments ventrad of oliva.

2. **Foramen of exit**—foramen lacerum posterius.

3. **Ganglia**—G. jugulare, in the proximal end of foramen of exit—G. inferius, 15mm. peripherad.

4. **Relations of ganglia**—G. jugulare, with NN. facialis (VII), glosso-pharyngeus (IX), accessorius (XI), sympathicus; G. inferius, with NN. glosso-pharyngeus (IX), accessorius (XI), hypoglossus (XII), pharyngeus, laryngeus superior, sympathicus.

5. **Px. gangliformis**—the 5 mm. of trunk peripherad of G. jugulare; it is formed by accessory portion of N. accessorius, anastomotic filaments between NN. vagus and accessorius, filaments to N. pharyngeus, and N. sympathicus.

6. **Principal rami**—respective origins and general distribution: Rm. auricularis, G. jugulare to N. facialis; N. pharyngeus, Px. gangliformis to Px. pharyngeus and œsophagæus; N. laryngeus superior, G. inferius to larynx; N. laryngeus inferior, N. vagus near arch of A. aorta to trachea and œsophagus; Rm. cardiaci, trunk of N. vagus proximad of base of heart to Px. cardiaci; Rm. pulmonares, trunk of N. vagus proximad of root of lungs to Px. pulmonares; anastomotic filaments to N. sympathicus.

7. **Bifurcation**—dorso-laterad from roots of lungs into lateral and mesal rami.

8. **Formation of nerve trunks**—dorsal trunk by union of lateral rami = dorsal gastric nerve (N. gastricus dorsalis)—ventral trunk by union of mesal rami = ventral gastric nerve (N. gastricus ventralis).

9. **Termination**—ganglia semi-lunaria of Px. solaris in loop of Wrisberg.

B. Physiological—sensibility of mucous membrane of pharynx, larynx, trachea, bronchi, bronchioli—motion of pharynx, larynx; reflex movements of broncho-pulmonary passages, œsophagus and stomach—action upon secretions, e. g., gastric juice, biliary products, etc.*—indirect influence upon phenomena of respiration and of "inhibition."

EXPLANATION OF THE NUMBERS AND ABBREVIATIONS USED IN THE FIGURES.

A. bas., A. basilaris; A. cb., A. cerebralis posterior; A. cbl., A. cerebellosa inferior; A. ver., Arteria vertebralis; Ar. el., area elliptica (possibly related to olivary body); ?, elongated, pyriform area lateral from Ar. el., whose homology is not determined; Cb., cerebrum; Cbl., cerebellum; Ch., chiasma; dpy., dorsipyramis (posterior pyramid); Ehr., G. Ehrenritteri; hph., hypophysis; I., G. inferius; J., G. jugulare; mtc., metacœlia (fourth ventricle); O., oliva, corpus olivarium (?); olf., lobus olfactorius; opt., N. opticus; Pe., G. petrosum; Px. ch., plexus choroideus lateralis; Px. phar., plexus pharyngeus; Pn., Pons Varolii; Rf., corpus restiforme; Vpy., ventripyramis (anterior pyramid); II., N. opticus; III., N. motor oculi; V., NN. trigemini; VI., N. abducens; VII., N. facialis; VIII., N. auditorius, Portio mollis; IX., N. glosso-pharyngeus; X., N. vagus; XI., N. accessorius; XII., N. hypoglossus; 1, accessory filament from N. glosso-pharyngeus; 2, Rm. auricularis; 3, anastomotic twig from J. to Pe.; 4, filament from origin line of IX. to 2; 5, ramulus from 2 to cochlea; 6, anastomotic twig to N. sympathicus; 7, chorda tympani; 8, anastomotic twig from Pe. to X.; 10, Rm. accessorius from XI.; 11, second accession from XI.; 12, anastomotic filaments between X. and XI.; 13, filament from XII. to I.; 14, Rm. from XI. to I.; 15, superior cervical ganglion of N. sympathicus; 16, pharyngeal ramus from IX. at Pe.; 17, anastomotic filament from 16 to I.; 18, anastomotic filament from 16 to Px. phar.; 19, filament from 16 to N. laryngeus superior; 20, cephalic ramus of IX.; 21, caudal ramus of IX.; 22, N. pharyngeus; 22 a, cephalic ramus; 22 b, caudal ramus; 23, filament from 22 to I.; 24, pharyngeal ramus of 22 b; 25, œsophageal ramus of 22 b; 26, filament from 25 to 22 a; 27, N. laryngeus superior; 28, cephalic = ental ramus; 29, caudal = ectal ramus; a, twig to 50; 30, pharyngeal ramus of 29; 31, filament from 30 to 25; 32, Rm. of 29 to Mb. crico-thyroidea; 33, to Cp. thyroideum, a, to descendens noni; 34, cephalic offset of 28; 35, filaments to interior of larynx; 36, to epiglottis; 37, to arytæno-epiglottidean folds; 38, caudal offset of 28; 39, twig from 34 to 38; 40, twig from 38 to M. arytænoideus, etc.; 41, palmate plexus; 42, ramus to 50; 43, N. cardiacus magnus sinister; 44, N. cardiacus minor; 45, origin of 50; 46, division of N. vagus sinister; 47, union of lateral rami; 48, union of mesal rami; 49, division of N. vagus dexter; 50, N. laryngeus inferior.

*The extent to which secretions and excretions may be referred directly to N. vagus is questionable.

Description of the figures.

Fig. 1.—General view of venter of brain ; special reference to venter of medulla, area post pontilis, showing relations of lines of origin-filaments of NN. glosso-pharyngeus, vagus, and hypoglossus ; also ectal relations, ventripyramis (vpy.), area elliptica (ar. el.), and the lateral tract (?).

Fig. 2.—View of sinistral surface of brain, special reference to curved line of origin-filaments of N. vagus and to origin line (L) ventrad, and their relations ; the cephalic filaments of N. accessorius (XI) are in the depression line ventral from Rf., while the caudal filaments have their origin in the depression line lateral from O.

Fig. 3.—Diagram to show the origin of N. vagus ventro-lateral to Rf. ; also that N. accessorius (XI) has its cephalic filaments from the same depression line, and its caudal filaments from the depression line ventro-lateral to O ; N. hypoglossus (XII) is dorso-lateral to ar. el.

Fig. 4.—Dorsal aspect of metencephalon (medulla) showing origins of NN. IX, X, XI ; metacœlia (mtc.), dorsipyramis (dpy.), corpus restiforme (Rf.), oliva (O), and the lateral tract (?).

Fig. 5.—To show relations of origin-filaments ; of Rm. auricularis ; of G. jugulare ; of G. petrosum ; of G. inferius. G. Ehrenritteri is removed from its normal relation which is ectal to G. jugulare, and is placed cephalad to expose the parts. N. XII, is reflected dorsad to expose origin of N. pharyngeus and anastomotic ramus from Pe. The dotted lines represent NN. hyo-thyroideus and descendens noni. Px. phar. = pharyngeal plexus.

Fig. 6. is Fig. 5, dissected to show Rm. accessorius given to J., and the second accession to the trunk peripheral to J. ; N. XII, is omitted as are the anastomotic filaments of Px. gangliformis ; the dotted line shows the direction of the filaments from N. XI, to N. pharyngeus.

Fig. 7.—N. laryngeus superior ; origin ; division ; distribution of ental or cephalic and ectal or caudal rami ; anastomotic relation between pharyngeal ramulus of the ectal ramus and the œsophageal ramus of N. pharyngeus.

Fig. 8.—N. laryngeus inferior. To show the laryngeal relations of N. laryngeus inferior ; entad of Ctl. thyroideus ; the palmate plexus ; the anastomotic filaments of NN. laryngeus superior and laryngeus inferior ; the pharyngeal ramus of N. laryngeus inferior (5°).

Fig. 9.—N. laryngeus inferior sinister. To show its origin ; relations with A. aorta and adjacent plexus ; relations of N. vagus with N. sympathicus ; division of N. vagus dorso-caudad of root of lungs ; the relations of the lateral and the mesal rami ; the dorsal and the ventral pulmonary plexus ; the formation and the relations of the dorsal and the ventral nerve trunks.

Fig. 10.—N. laryngeus inferior dexter. To show its origin ; its relations with A. subclavia ; relations of N. vagus with N. sympathicus.

Fig. 11 and 12.—Tracheo-œsophageal ramuli of N. laryngeus inferior sinister and dexter respectively.

Fig 13.—Distribution and relations of the ventral gastric nerve and the ramus which terminates in the dextral G. semilunare of Px. solaris.